Rhabdomyolysis

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Historical Data

- Classic description of acute renal failure associated with crush injury occurred in London Blitz,in 1940
- All of the patients were buried for 3-4 hours
- All of the patients had hyperkalemia early and this led to early deaths

Military Experience

- WII 450,000 deaths
- Overall mortality of combat casualties 28%
- Evacuation time was long 6-8hrs
- True incidence of ARF during WWII unknown
- High mortality rate for ARF in Italian campaign, 91% mortality figure

Korean Conflict

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- Overall mortality of combat casualties decreased to 22%
- Evacuation and resuscitation techniques improved
- Incidence of ARF 1 in 200 in seriously injured
- Mortality rate was 84% pre-dialysis, and 53% after dialysis was introduced.

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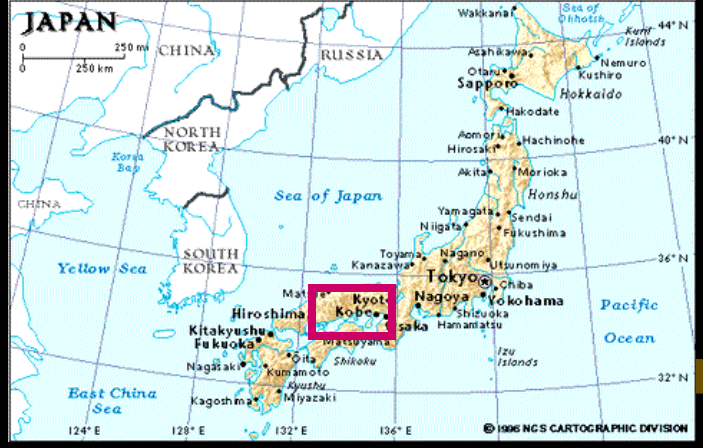
Vietnam

- Overall all mortality of combat causalities decreased to 13%
- Evacuation, resuscitation techniques improve
- ARF 1 in 600 seriously injured
- ARF mortality similar at (63-70%)



KOBE

- 372 Myoglobinuric ARF secondary to crush injury
- Rescuers unfamiliar with recent treatment recommendations
- Retrospective review showed many cases could have been prevented

SKELETAL MUSCLE

- 40 to 50% of total body weight
- Highly exposed/susceptible to mechanical trauma
- Largest single pool of body water
- 70% of total body potassium
- Largest concentration of Na/K ATPase

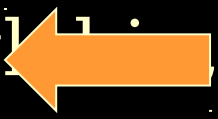
Sarcolemma

- Impermeable to extracellular fluid and its cations
- Prevents hyperoncotic cytosol from massive ECF flooding
- Na/K ATP pumps, maintain these gradients and cytosolic electronegativity

Rhabdo

- ECF Cytosol
- Calcium, Sodium,water

ECF Cytosol



Myoglobin Potassium,Purines

ELECTROLYTE DISORDERS

- Occur within 2 hours
- Hyperkalemia
- Hypocalcemia
- Hypophosphatemia
- Hyperuricemia
- Metabolic acidosis

ECF
Cytosol

- Massive Na, Water shifts causes profound volume depletion
- Hypovolemic shock
- Calcium shifts lead to severe hypocalcemia and calcium deposition into muscle cytosol

Circulatory Failure

- Massive uptake of ECF by swollen muscles upto 14 L within hours
- Negative intropes (hyperkalemia,hypocalcemia)
- Profuse vasodilatation with exception of intense renal constriction

Renal Vasoconstriction

- Vasoconstrictors are released by baroreceptors
- Myoglobin chelates renal nitric oxide
- End result is intense renal vasoconstriction and ischemia

Nephrotoxins

- Phosphate
- Purines
- Myoglobin
- All of these are nephrotoxins especially with underlying volume depletion, aciduria, and increased urinary concentration.

Morphologic alterations

- Formation of heme casts in distal tubules
- Proximal tubular necrosis
- Tubular cast cause obstruction and stasis
- Renal ischemia + tubular toxins with profound electrolyte abnormalities.

Those at risk

- Trauma
- Severe muscle exertion
- Untrained individuals
- Sickle cell trait
- Alcohol
- Other drugs (HMG CoA, AZT)
- Metabolic derangements, viral infections

Treatment

- Early massive volume repletion
- Volume repletion should be started in the early in the field.
- If victim is buried, start saline infusion once a limb is available
- Saline should be given a 1 Liter /hour

Monitoring

- Blood pressure
- Central venous pressures
- Urinary output

Daily volume requirements

- Urine flow should be maintained at 8 L/day
- Total amount of fluid required to maintain this rate is usually 12 liters day
- + balance of fluid 4 L day/sequestered in the limbs

Bicarbonate Infusions

- Should be given once patient is in a monitored setting
- 200-300 mEq for the first day but can be highly variable
- 1 amp= 50 mEq, needs to be infused in D5W or 1/2 NS
- Maintain urine pH above 6.5

Benefits & Complications

- Ameliorate the hyperkalemia
- Acts as non-absorbed solute inducing diuresis
- Increases the solubility of heme pigments and minimizes the conversion of hemoglobin to the more toxic methemoglobin

Complication of Alkalinization

- Potential to exacerbate the hypocalcemia and thus induce seizures and more extensive muscle damage.
- May cause further calcium phosphate precipitation.

Mannitol

- Once urinary flow is established, Mannitol can be added at 20% solution at rate of 1-2 g/kg over 4 hours.
- Usually given as 1/2 NS with 10g mannitol and 40mEq bicarbonate, alternating with normal saline
- Maximum dose should not exceed 200g/24hrs

Contraindications to Mannitol

- Should not be given to a patient who has established anuria
- If patient is anuric after initial volume resuscitation, may attempt one time bolus of 20 g mannitol with Lasix 120mg
- Plasma osmol gap should remain below 55mOsm/kg

Benefits of Mannitol

- Main benefit from forced diuresis, which minimizes pigment deposition and cast formation
- May act as free radical scavenger
- No amelioration of tubular necrosis
- May decompress edematous muscles and protect against further rhabdomyolysis

Duration of therapy

- Urine output should be maintained at 300cc/hr until urine myoglobin has cleared
- Alkalinization and mannitol should also be continued until urine myoglobin has cleared
- Majority of patients with established myoglobinuric ARF will ultimately have full recovery

Late complications

- Compartment syndrome
- Swelling of injured muscles will increase interstitial pressure and tamponade off local blood supply
- Hypercalcemia can develop in recovery stage secondary to mobilization of calcium deposited in injured muscle.

Early Evacuation

- Hyperkalemia can be massive
- Outcomes improved in previous conflicts with dialysis availability

Treatment of Hyperkalemia

- Calcium 1 ampule or 5-10 ml of 10% calcium gluconate over 2 minutes
- D50 1 amp with 10 units of insulin over 5 minutes
- Kayexalate 30-60 gms in 20% sorbitol, can only be used with functional bowel
- Beta 2 agonist (albuterol)